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BREEDING CROP AND HERBAGE PLANTS IN NEW ZEALAND

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in New Zealand, and to discuss the impact of this work for the benefit of less developed areas.

2. Organisation of Plant Breeding in New Zealand

The breeding of herbage and crop plants is almost wholly the responsibility of government institutions. Pasture plant breeding is carried out by the Grasslands Division, Department of Scientific and Industrial Research, Palmerston North, and the breeding of crop and vegetable plants by the Crop Research Division of the same Department at Lincoln. Testing of varieties is performed by the Department of Scientific and Industrial Research and the Department of Agriculture. The responsibility for ensuring that seed of improved varieties reaches the user true to label rests on the Department of Agriculture, which administers a Government Seed Certification Scheme. The effectiveness of this scheme in ensuring that the user obtains seed of guaranteed strain is demonstrated by the following figures for three of the most important pasture species used in New Zealand - perennial ryegrass, cocksfoot and white clover. Of the total seed harvest for the year 1961 the percentage certified was 81, 67 and 94 per cent for perennial ryegrass, cocksfoot and white clover respectively.

3. Pasture Plant Breeding

Most of New Zealand was clothed in rain forest not much more than a century ago. Natural grassland was restricted to the Central Plateau of the North Island and the foothills and part of the plains to the east of the mountain ranges of the South Island. Sown grasslands now occupy land formerly in forest together with some of the area previously in natural grassland. For the sown grasslands, species of grasses and legumes introduced from overseas by the early settlers have been used.

(a) The prime objective in the breeding of pasture plants is improvement in yield and seasonal spread of production. Although the temperate climate of New Zealand permits of pasture growth throughout most of the year, there are nevertheless periods in winter and summer when production is not sufficient to meet animal requirements. These periods of shortage can be overcome to some extent by the use of species and strains bred for extended seasonal production. Other objectives in the plant breeding projects include improvement of persistency, palatability to stock, disease resistance, seed production and uniformity of flowering.

4. Plant Breeding Procedure

Most pasture plants are normally cross-pollinated, set very few seeds from self-pollination and exhibit marked reduction in vigour when inbred. For these reasons improved strains are "synthetics" based on a number of unrelated plants. The basic plant material for many of the improved strains has been selected from New Zealand ecotypes but in some cases genetic

diversity has been obtained by interspecific hybridization. In the former category are the certified strains of perennial ryegrass and white clover and in the latter is short-rotation ryegrass. This strain was based on hybrids between Italian and perennial ryegrass to obtain the high winter production of the former together with greater persistency derived from the latter.

(a) Selection and progeny testing are based on the polycross technique which permits large populations to be tested and sufficient seed to be obtained from individual plants to allow of sward trials as well as individual plant tests. After several generations of selection a number of unrelated plants of the required type and of high combining ability are selected as the nucleus of the new strain.

(b) Up to the present the aim has been to produce strains adaptable to a wide range of environmental conditions rather than regional strains suited to a comparatively narrow environment. Pasture strains bred in New Zealand have proved to be well suited to other countries where the environment is not greatly dissimilar to that in New Zealand. Pasture plant seeds to the value of some £1,700;000 annually are exported to other countries, mainly the United Kingdom and Australia.

(c) Before the release of seed of a new strain, trials are carried out throughout the country at research stations and on farms in collaboration with the Department of Agriculture. If the new strain proves superior to any others, seed is produced and distributed under the Government Seed Certification Scheme.

5. Bred Strains of Herbage Plants

Improved strains have been produced and certified seed made available of the following grasses and legumes:- ryegrasses (Lolium spp.), cocksfoot (Dactylis glomerata), timothy (Phleum pratense), white clover (Trifolium repens), red clover (T. pratense), and lucerne (Medicago sativa). Each of these species and strains has its own seasonal growth potential which can be utilized to assist in equating pasture production throughout the year to the feed requirements of the grazing animal. The basic species for high-producing pastures are perennial ryegrass and white clover, from which, under favourable conditions of moisture, fertility and grazing utilization, an annual production of 14,000 lb of dry matter with a protein content of 20 per cent can be obtained. But neither of these plants is high-producing in the winter and late summer. Seasonal production can be extended by the use of better winter-growing plants such as short-rotation ryegrass and summer growers such as cocksfoot, red clover and lucerne.

(a) But different species and strains respond differently to grazing management. Perennial ryegrass and white clover, for example, will thrive under severe defoliation which would be fatal to cocksfoot and lucerne. To be fully effective a pasture

plant breeding programme must be associated with ecological research to determine the reaction of bred strains to the environmental factors to which they will be subjected. In New Zealand such collaborative research has contributed to an understanding of the management requirements of bred strains and has enabled the farmer to make the most of their potentialities for high production. The use of compatible species in pasture mixtures, the adoption of sound grazing management and the use of practices designed to maintain soil fertility are all factors which contribute to the realization of high and sustained pasture production throughout the year.

6. Forage Crops

The area devoted to forage crops, which are grown as a supplement to pasture, is 750,000 acres, which is only 4 per cent of the sown grassland, and indicates the reliance that the farmer places on grassland and grassland products in the form of hay and silage to provide stock feed. Nevertheless, particularly in the South Island where the summers and winters are more extreme than they are in the north, an area in crop can be a valuable insurance against feed shortage.

(a) The value of a supplementary crop is directly related to its reliability, for it is grown to provide stored food for use when pasture production is low. The most important factors which cause reduction in crop yields, apart from the vagaries of climate, are pests and diseases, and so the main approach by the Crop Research Division to forage plant improvement has been the breeding of varieties resistant to pests and diseases.

(b) The most important forage crops are brassicas, including the kales (Brassica oleracea), rapes (B. napus), turnips (B. campestris) and swedes (B. napus). The area devoted to these crops is more than 90 per cent of the total area of supplementary forage crops grown.

(c) Eight brassica varieties resistant to various pests and diseases have been produced. An aphid-resistant rape has been bred by transferring resistance from swedes, and a variety resistant to clubroot has been selected. Breeding is now in progress to combine aphid resistance and clubroot resistance in the one variety. Varieties of swedes are available with resistance to clubroot and others with resistance to dry-rot and work is underway to combine resistance to both diseases in the one variety. With turnips, breeding is being undertaken to transfer clubroot resistance from late to early-maturing varieties and to transfer virus resistance from swedes to turnips.

(d) The breeding of these brassica varieties resistant to pests and diseases has increased stock carrying capacity by providing an additional insurance to the farmer against feed shortages in the seasons critical to pasture production.

7. Food Crops

Improved varieties of some 20 cereal and vegetable crops produced by the Crop Research Division are at present used in New Zealand. It is not proposed to enumerate these varieties but rather to discuss briefly two examples as illustrations of the effectiveness of plant breeding in increasing food resources.

(a) Wheat

New Zealand is not self-supporting in wheat but some 180,000 acres are grown annually, mainly in the arable areas of the South Island, and practically all of this acreage is of varieties produced by the Crop Research Division. For many years the variety Cross 7 was the predominant wheat but it has now given way to the variety Aotea. This wheat is similar to Cross 7 in most agronomic characters and in milling and baking quality but the average yield is some 25 per cent greater. The effect of the release of a high-producing variety in raising average yields is shown by a comparison of yields in 1952 and 1960, two years when reliable statistics were obtained from a complete coverage of threshing returns. In 1952, when Cross 7 was the predominant variety, the average yield was 42 bushels per acre. By 1960 when the variety Aotea, released in 1957, accounted for 86 per cent of the wheat area, the average yield was 53 bushels per acre, an increase of 23 per cent over that in 1952.

(i) The ready acceptance by the farmer of an improved variety is demonstrated by the rapid increase in popularity of Aotea after the initial release of a small quantity of certified seed. Within three years 86 per cent of the wheat harvested for milling was of this variety.

(b) Sweet Potato

In many of the Pacific Islands the sweet potato (Ipomoea batatas) serves as a subsistence crop of high nutritive value.

(i) Yen (1) has collected plant material from extensive geographical regions including New Zealand, South East Asia, Melanesia, Polynesia and South America, and is using this material as the basis for improvement of local varieties and those of certain of the Pacific Islands. A collection of some 350 varieties is being studied and maintained at the Vegetable Station of the Crop Research Division. By selection and breeding it is hoped to produce varieties with improved yield, tuber shape, field and storage disease resistance, storage quality and nutritive value. The adaptability of varieties to different geographical regions is being studied; plant material from the collection has been sent to Fiji, Cook Islands, Niue and New Guinea. Barriers to plant breeding, including non-flowering of

(1) Yen, D.E., The improvement of some subsistence crops in the Pacific, Symposium on Tropical Crops Improvement, South Pacific Commission (1962).

clones and self- and cross-sterility are being investigated.

(ii) Selection from this wide range of material is already revealing promising varieties. A clone with improved yield, tuber shape and keeping quality has been selected and is at present being increased for field and storage trials.

8. Impact of Plant Breeding in New Zealand on Less Developed Areas

(a) The examples quoted on the improvement of herbage and crop plants give some indication of the contribution of plant breeding towards increasing food in a well developed country. In the long run the most effective method of increasing food in underdeveloped countries is by technical improvement of the agriculture of the country itself. As the initial step in this direction the developed country can serve as a pattern for the underdeveloped. For instance, the relatively high standard of grassland farming in New Zealand and some other highly developed grassland countries is at present being used as a pattern for the development of grasslands in Japan. Although arable farming in Japan is highly efficient modern grassland farming has never been practised.

(i) The diet of the Japanese is deficient in animal protein, consumption per head being only 9 per cent. of that in this country. The Japanese Government has launched a long-term agricultural development plan under which it aims by 1975 to have increased the production of animal proteins to four times the present figure. To do this, it proposes in this period to increase the population of dairy cows from 1 million to 4 million, beef cattle from 2½ to 4 million, sheep from 1 to 3½ million and poultry from 45 to 96 million. To assist in providing food for the increased animal population it is proposed to convert a large proportion of the extremely low-producing natural grassland to high-producing sown grassland.

(ii) Under the auspices of F.A.O. New Zealand is serving as a pattern for the technical improvement of grassland farming through visits of New Zealand specialists to Japan and Japanese personnel to New Zealand. In this way it is hoped that the principles and techniques applied in New Zealand, with appropriate modifications to suit the conditions, will serve as a model for the development of high-producing grasslands and efficient local production of animal protein food in Japan.

(b) Research in one country can have a more direct impact on food production in an underdeveloped country than in the example quoted above. It may be that improved plant varieties, when grown in a country where no plant breeding or selection has been practised, will prove superior to any local varieties. This was the case with some of the corn hybrids tested by F.A.O. in the early stages of its European Hybrid Corn Project. (2) The first stage of this project was the testing of some of the United States and Canadian hybrids

in European countries where corn yields were low. Some of these hybrids showed considerable increases in yield in spite of the fact that they were not bred for the specific conditions under which they were tested. From 300 trials carried out by F.A.O. in 14 countries outside North America it was found that the best of 45 United States and Canadian hybrids out-yielded the best open-pollinated local varieties by an average of 50 per cent.

(i) It is likely that some of the sweet potato varieties now being investigated in New Zealand could prove superior in certain of the Pacific Islands to the varieties at present being used there. Botanical analysis by Yen of geographic populations from South East Asia, Melanesia, Polynesia and South America has shown that varieties in the Cook Islands, Tonga, Fiji and New Guinea represent a relatively narrow spectrum of the variation in the species. Plant material from the collections being maintained in New Zealand is being sent to some of these Pacific regions for testing against the material at present being used there.

(ii) The provision of this plant material should be considered as only the first stage in a plant improvement project. It is probable that the testing of this plant material against local varieties will reveal varieties more valuable than those now grown there. But if this initial work is to be really effective it will need to be developed to the stage where plant breeding is done in the country itself. Following the initial testing of a range of new plant material and the introduction into local agriculture of superior varieties emanating therefrom, further improvement would require the setting up of a plant breeding organisation with requisite facilities and trained personnel. Significant improvement in varieties could be expected by the use of known plant breeding methods. If the country is receptive to such development, but does not have the requisite facilities and technical knowledge, there is a case for assistance by such agencies as F.A.O. to stimulate development by the initial provision of facilities and technical personnel. Such collaborative assistance would offer to underdeveloped countries the opportunity of improving their own food resources.

(2) Co-operative hybrid maize tests in European and Mediterranean countries, F.A.O. Development Paper No. 42 (1952)